Niazi Journal of
Medical & Dental Sciences

Original Article

Malnutrition and its determinants among tuberculosis patients in Lahore, Pakistan

Mohammed Khudhair Hasan [a], Khadija Tariq [b,c,*]

[a] Department of Pharmacy, Ibn Khaldoon Private University College, Iraq
[b] Hussain College of Health Sciences, Lahore, Pakistan
[c] PhD (Scholar) HND, University of Management and Technology, Pakistan

* Correspondence: khadijaquresh97@gmail.com

Check for updates

Citation: Hasan MK, Tariq K. Malnutrition and its determinants among tuberculosis patients in Lahore, Pakistan. Niazi J Med Dent Sci. 2025;1:35-45.

Received: 16 June 2025
Revised: 08 December 2025
Accepted: 15 December 2025
Published: 31 December 2025

Abstract

Tuberculosis (TB) and malnutrition are closely intertwined, yet local data on the nutritional status of TB patients and the factors that shape it remain limited in Pakistan. This cross-sectional study determined the nutritional status of adult TB patients attending public- and private-sector hospitals in Lahore and identified its sociodemographic and health-system determinants while also describing treatment-related and facility-related barriers and their relationships with treatment adherence. A total of 379 adult patients receiving anti-TB treatment were assessed using the 18-item Mini Nutritional Assessment (MNA), and treatment, facility, and patient experiences were recorded through a structured proforma. Nutritional status was classified using standard MNA cut-offs, and determinants of malnutrition and self-reported nonadherence (≥ 2 missed doses in two weeks) were examined using the chi-square test and multivariable logistic regression. The mean MNA score was 15.2 ± 6.1, and malnutrition was highly prevalent: 183 patients (48.3%) were malnourished, and 154 (40.6%) were at risk, leaving only 42 (11.1%) with a normal nutritional status. Female sex (adjusted odds ratio [aOR] 1.59, 95% confidence interval [CI] 1.04–2.44; $p = 0.032$) and rural residence (aOR 1.74, 95% CI 1.11–2.72; $p = 0.015$) were independently associated with malnutrition, and a higher patient-barrier score showed a borderline association (aOR 1.25, 95% CI 1.00–1.56; $p = 0.048$), whereas age and treatment or facility burden were not; household income was associated with malnutrition bivariately but not after adjustment. Self-reported nonadherence, reported by 293 patients (77.3%), was associated with a higher facility-barrier burden (aOR 1.59, 95% CI 1.08–2.34; $p = 0.020$) but not with nutritional status. The study concluded that malnutrition or its risk affects the overwhelming majority of TB patients in this setting, with women and rural patients at greatest risk, while facility-level barriers—rather than nutritional status—track with missed doses. Nutrition-sensitive TB care that prioritizes women and rural patients, coupled with health-system measures to ease facility barriers, is warranted.

Keywords

Health system barriers; Malnutrition; Mini Nutritional Assessment; Pakistan; Treatment adherence; Tuberculosis

1. Introduction

Few infectious diseases still exact the toll that tuberculosis (TB) does [1]. Global surveillance for 2023 revealed approximately 10.8 million new episodes of illness and 1.25 million deaths, restoring TB to its position as the deadliest single-pathogen infection worldwide. That toll falls unevenly: five countries—India, Indonesia, China, the Philippines and Pakistan—carry 56% of it between them, with Pakistan's own share standing at

6.3% [2]. Pakistan ranks fifth among the thirty high-burden countries and reports approximately half a million new cases annually, a burden compounded by drug resistance, underfunding, and constrained health-system capacity [3].

Undernutrition and TB are bound together in a self-reinforcing cycle [4]. Undernutrition weakens both innate and adaptive immunity, increasing the risk that latent infection progresses to active disease, whereas active TB increases metabolic demand, suppresses appetite, and deepens nutritional depletion [5]. At the population level, undernutrition is estimated to drive more TB cases than HIV cases, and it is associated with greater disease severity, poorer treatment response, and a roughly twofold higher risk of death [5,6]. The relationship is clinically actionable: nutritional supplementation of patients and their household contacts has been shown to reduce TB incidence and mortality, underscoring that nutrition is not merely a marker of disease but also a modifiable determinant of outcome [7].

Given this bidirectional link, routine nutritional assessment is recommended throughout TB care [6]. The Mini Nutritional Assessment (MNA) is a widely validated, 18-item instrument that combines anthropometry, dietary intake, global and self-perceived health, and a rapid screening subscale, and it classifies patients as well-nourished, at risk, or malnourished [8,9]. Although it was developed for older adults, its multidimensional structure makes it well suited to chronic wasting conditions such as TB, and it has been applied to TB populations elsewhere [10]. Studies across South Asia and sub-Saharan Africa have reported undernutrition in 40–60% of adult TB patients, with female sex, rural residence, low income, dietary inadequacy, and a lack of nutritional counseling repeatedly being reported [11,12,13].

Nutritional vulnerability does not act in isolation; it is embedded in wider treatment experience [14]. Anti-TB therapy is long and demanding, and side effects, pill burden, cost, and the practical difficulty of reaching care can all erode adherence, itself being a principal driver of treatment failure, relapse, and drug resistance [15,16]. In Pakistan, qualitative work has consistently identified limited awareness, financial hardship, stigma, and distance from health facilities as barriers to adherence and has highlighted the particular disadvantages faced by women and rural residents in reaching care [15,17,18]. However, most local studies have examined nutritional status and adherence separately, and few have quantified how sociodemographic position and health-system barriers jointly shape nutritional status and treatment behavior in the same cohort [19].

In light of this background, the present study was conducted among adult TB patients who attended public- and private-sector hospitals in Lahore, Punjab. Its primary objective was to determine the nutritional status of these patients and identify the sociodemographic and health-system factors independently associated with malnutrition. Its secondary objectives were to describe the treatment-related, facility-related, and patient-related barriers experienced during therapy and to examine the association of nutritional status and these barriers with self-reported nonadherence. By analyzing nutritional status and adherence together, this study aims to provide baseline evidence to inform nutrition-sensitive, patient-centered TB care in this high-burden setting.

2. Methods

2.1. Study duration and ethical considerations

The study was conducted over a period of six months, from April to September 2024. Ethical clearance was granted in advance by the Ethical Review Committee of Hussain College of Health Sciences, Lahore, Pakistan (No. HCHS/2024/ERC/59), and the work followed the principles set out in the Declaration of Helsinki. Informed consent was obtained from every participant before enrollment. Participation was entirely voluntary, the purpose of the study and the confidentiality of the information were explained to each participant, responses were anonymized before analysis, and participants were free to withdraw at any stage without any effect on the care they received.

2.2. Study design and setting

Adults undergoing anti-TB treatment in Lahore—Punjab's capital and Pakistan's second-largest city—formed the study population for this descriptive, cross-sectional survey. Participants were recruited from two sites representing both sectors of the local health system: Lahore General Hospital, a large public-sector tertiary care facility, and Hussain Memorial Hospital, a private-sector facility. Together, these facilities serve a large and socioeconomically diverse population drawn from both urban Lahore and the surrounding rural areas and provide TB care in line with the National TB Control Programme's directly observed treatment framework.

2.3. Study population and eligibility

Anyone aged 18 years or older with a confirmed TB diagnosis who was registered for anti-TB treatment at the participating facilities and who consented to participate was eligible. Three groups were excluded: patients who were too unwell to be interviewed, those for whom anthropometric measurements could not be carried out, and those who preferred not to participate.

2.4. Sample size and sampling

Regional estimates place malnutrition at approximately half of all adult TB patients [11,20]; taking 50% as the expected proportion and allowing a 5% margin of error at 95% confidence, the calculation returned 384 as the minimum number needed. Consecutive eligible patients who attended the TB clinics during the study period were invited to participate, and 383 records were collected. Four records were excluded during data cleaning because misaligned data entry produced out-of-range values that could not be reliably reconstructed (two of these were also duplicate entries), leaving 379 records for analysis. The resulting margin of error (5.03%) is negligibly different from that assumed in the calculation.

2.5. Data collection tool

Data were collected through a structured, interviewer-administered proforma comprising several sections: patient history and TB clinical details; a sociodemographic profile; the full 18-item MNA; and blocks capturing treatment-related, healthcare-facility-related, and patient-related experiences during therapy. The MNA combines a six-item screening subscale (recent food intake, weight loss, mobility, psychological stress, neuropsychological status, and body mass index) with a twelve-item assessment subscale covering living situation, polypharmacy, comorbidity, meal frequency, protein, fruit and vegetable and fluid intake, mode of feeding, self-perceived nutrition and health, and mid-arm and calf circumference [8,9]. Items were scored according to the standard MNA algorithm to yield a total score out of 30.

2.6. Study variables and definitions

The primary outcome was nutritional status, which was classified on the basis of the total MNA score as normal (≥ 24), at risk of malnutrition (17–23.5), or malnourished (< 17); for regression, malnutrition was analyzed as a binary outcome (malnourished versus not) [8]. A secondary outcome, self-reported nonadherence, was defined as two or more anti-TB doses missed during the preceding two weeks. Three composite barrier scores were derived by summing the binary items of the treatment-related (eight items), facility-related (seven items), and patient-related (ten items) blocks, with each item coded so that a higher value denoted a more adverse experience; positively worded items were reverse-coded before summation. The sociodemographic covariates included age, sex, marital status, residence (urban/rural), monthly household income, and education.

2.7. Statistical analysis

The data were analyzed in IBM SPSS version 27.0. Distributions of continuous variables were examined using the Shapiro–Wilk test; because all the variables departed from normality, these variables are presented as the mean ± standard deviation (SD) for comparability with the published literature, with medians and interquartile ranges (IQRs) reported alongside the principal measures, and nonparametric tests were used throughout; categorical variables are expressed as frequencies and percentages. Bivariate associations of sociodemographic factors and barrier domains with malnutrition and nonadherence were tested using the Pearson chi-square test (or Fisher's exact test where expected cell counts were < 5), with crude odds ratios (ORs) and 95% confidence intervals (CIs); continuous barrier scores were compared between outcome groups using the Mann–Whitney U test. Because several comparisons were made against each outcome, the Benjamini–Hochberg procedure was applied within each family of bivariate tests to control the false discovery rate, and adjusted *p* values are reported alongside the raw values. Two multivariable binary logistic regression models were then fitted—one for malnutrition and one for nonadherence—each adjusting simultaneously for age, sex, residence, income, and the three barrier scores, with the nonadherence model additionally including malnutrition status. Adjusted odds ratios (aORs) with 95% CIs are reported, and model fit is summarized by the likelihood ratio (LR) test and McFadden's pseudo-R^2. Because mid-arm and calf circumference and the other MNA items constitute the MNA score, they were not entered as predictors of the MNA-derived outcome. All tests were two-sided, and a p value < 0.05 was considered to indicate statistical significance.

3. Results

3.1. Sociodemographic profile and nutritional status

A total of 379 adult TB patients were analyzed. The mean age was 43.0 ± 17.3 years (median 40.0, IQR 29.0–57.0), and the mean duration of formal education was 8.1 ± 4.9 years. Most participants were male (56.5%), married (77.0%), and urban residents (52.8%), and the largest income group earned more than PKR 100,000 per month (42.5%). The mean total MNA score was 15.2 ± 6.1 out of 30 (median 17.0, IQR 10.0–18.0). Malnutrition was highly prevalent: 183 patients (48.3%) were malnourished, and 154 (40.6%) were at risk of malnutrition, leaving only 42 (11.1%) with a normal nutritional status (Table 1).

Table 1. Sociodemographic characteristics and nutritional status of the TB patients (N = 379).

Characteristic		**n (%)/Mean ± SD**
Age (years)		43.0 ± 17.3
Education (years)		8.1 ± 4.9
Sex	Male	214 (56.5)
	Female	165 (43.5)
Marital status	Married	292 (77.0)
	Unmarried	87 (23.0)

Characteristic		n (%)/Mean ± SD
Residence	Urban	200 (52.8)
	Rural	179 (47.2)
Monthly income (in PKR)	< 20,000	20 (5.3)
	20,000–50,000	128 (33.8)
	50,001–100,000	70 (18.5)
	> 100,000	161 (42.5)
Nutritional status (MNA)	Normal	42 (11.1)
	At risk of malnutrition	154 (40.6)
	Malnourished	183 (48.3)

* MNA, Mini Nutritional Assessment; PKR, Pakistani Rupees. ** Nutritional status classified by total MNA score (normal ≥ 24; at risk 17–23.5; malnourished < 17).

3.2. Determinants of malnutrition

In the bivariate analysis, female sex (55.8% vs 42.5% among men; $p = 0.014$), rural residence (55.3% vs 42.0% among urban patients; $p = 0.013$), household income ($\chi^2 = 11.88$, df = 3, $p = 0.008$) and a higher patient-barrier score (median 6 vs 5; Mann–Whitney $p = 0.006$) were associated with malnutrition, whereas age, marital status, and the treatment-burden and facility-barrier scores were not. All four associations remained significant after Benjamini–Hochberg correction for the eight comparisons made against this outcome (adjusted $p = 0.028$ for each). The income association was not monotonic across categories—malnutrition affected 70.0% of patients earning less than PKR 20,000 per month, 43.8% of those earning 20,000–50,000, 35.7% of those earning 50,001–100,000 and 54.7% of those earning more than 100,000—and rested in part on a small lowest-income group (n = 20). In the multivariable model, female sex (aOR 1.59, 95% CI 1.04–2.44; $p = 0.032$) and rural residence (aOR 1.74, 95% CI 1.11–2.72; $p = 0.015$) remained independently associated with malnutrition, and the patient-barrier score retained a borderline association (aOR 1.25 per additional barrier, 95% CI 1.00–1.56; $p = 0.048$). Income was no longer associated after adjustment (aOR 1.10, 95% CI 0.69–1.74; $p = 0.70$), indicating that its bivariate association was accounted for by the other factors in the model. The overall model was statistically significant (LR $\chi^2 = 17.6$, df = 7, $p = 0.014$); neither the treatment-burden nor the facility-barrier score was independently associated with malnutrition (Table 2).

Table 2. Bivariate and multivariable analyses of factors associated with malnutrition (malnourished versus not; N = 379).

Factor	Crude OR	aOR (95% CI)	*p* (Adjusted Model)
Female (versus male)	1.70	1.59 (1.04–2.44)	0.032 ***
Rural (versus urban)	1.70	1.74 (1.11–2.72)	0.015 ***
Age (per year)	1.01	1.00 (0.99–1.01)	0.93
Low income (< 50,000)	0.94	1.10 (0.69–1.74)	0.70
Treatment-burden score	-	1.03 (0.87–1.22)	0.76
Facility-barrier score	-	1.03 (0.77–1.37)	0.86
Patient-barrier score	-	1.25 (1.00–1.56)	0.048 ***

* OR, odds ratio; aOR, adjusted odds ratio; CI, confidence interval. ** Overall model LR $\chi^2 = 17.6$, df = 7, $p = 0.014$; McFadden pseudo-$R^2 = 0.03$. *** Significant value ($p \leq 0.05$). **** Continuous barrier scores were entered directly into the adjusted model. ***** Crude odds ratios are not reported for the continuous barrier scores; these were compared between outcome groups using the Mann–Whitney U test (see Section 3.2).

3.3. Treatment, facility, and patient-related barriers

Treatment-related burdens were reported by the great majority of patients: 93.7% perceived the treatment course as too long, 91.6% considered the number of drugs excessive, 88.7% had stopped medication because of side effects at some point, and 86.3% reported discomfort after taking their drugs, while the cost was a concern for approximately three-quarters (74.1%). Most core facility indicators were, by contrast, favorable—more than nine in ten patients reported convenient travel to care (91.3%), receipt of treatment recommendations (97.9%), a receptive physician (92.9%), and easy local drug availability (94.7%), although approximately one in four (24.0%) reported a consultation journey exceeding 60 minutes. Patient-related distress and access difficulties were common, including feeling depressed about the disease (95.3%), an appetite affected by drugs (91.3%), a distant TB reference unit (79.2%), and difficult transport (45.9%) (Table 3).

Table 3. Treatment-related, facility-related, and patient-related experiences reported by TB patients (N = 379).

Item	Domain	Reported, n (%)
Treatment course feels too long	Treatment	355 (93.7)
Amount of TB drugs is too much	Treatment	347 (91.6)
Ever stopped drugs due to side effects	Treatment	336 (88.7)
Discomfort after taking TB drugs	Treatment	327 (86.3)
Perceives treatment cost as too high	Treatment	281 (74.1)
> 60 min to reach consultation	Facility	91 (24.0)
Poor support from health staff	Facility	18 (4.7)
Drugs not easily available locally	Facility	20 (5.3)
Often feels depressed about the disease	Patient	361 (95.3)
Appetite affected by drugs	Patient	346 (91.3)
TB reference unit far from home	Patient	300 (79.2)
Transport difficult (distance or cost)	Patient	174 (45.9)
Often forgets to take medication	Patient	54 (14.2)

The items shown are the highest-frequency items in each domain together with those referred to in the text; selection was made a priori and not on the basis of association with either outcome. Composite scores (mean ± SD): treatment burden 5.8 ± 1.2 (range 0–8), facility barriers 1.5 ± 0.7 (0–7), patient barriers 5.5 ± 1.0 (0–10). The full item list for all three domains is available from the authors upon request.

3.4. Determinants of nonadherence

Self-reported nonadherence, defined as two or more missed doses in the preceding two weeks, was common, affecting 293 patients (77.3%). Among the factors examined, only the facility-barrier domain was associated with nonadherence, whether analyzed as a dichotomy (higher facility burden: 84.7% vs 72.1% nonadherent; crude OR 2.12, 95% CI 1.24–3.62; $p = 0.006$), as a continuous score (Mann–Whitney $p = 0.008$), or after adjustment (aOR 1.59, 95% CI 1.08–2.34; $p = 0.020$). The bivariate association did not, however, retain significance after Benjamini–Hochberg correction for the eight comparisons made against this outcome (adjusted $p = 0.062$), although the association persisted in the adjusted model. Sociodemographic factors, treatment burden, patient-related barriers, and nutritional status were unrelated to nonadherence (Table 4).

Table 4. Multivariable logistic regression for nonadherence (≥ 2 missed doses in two weeks; N = 379).

Predictor	aOR	95% CI	*p* Value
Facility-barrier score	1.59	1.08–2.34	0.020 ***
Malnourished (versus not)	1.46	0.88–2.42	0.14
Treatment-burden score	1.17	0.95–1.43	0.15
Patient-barrier score	1.08	0.83–1.40	0.59
Age (per year)	0.99	0.98–1.01	0.40
Female (versus male)	1.07	0.64–1.78	0.81
Rural (versus urban)	1.09	0.64–1.85	0.76
Low income (< 50,000)	0.67	0.39–1.14	0.14

* aOR, adjusted odds ratio; CI, confidence interval. ** Overall model LR $\chi^2 = 13.2$, df = 8, $p = 0.11$; McFadden pseudo-$R^2 = 0.03$. *** Significant value ($p \leq 0.05$).

4. Discussion

This cross-sectional study of adult TB patients in Lahore revealed a strikingly high burden of malnutrition: nearly half of the patients were malnourished, and an additional two-fifths were at risk, leaving only approximately one in nine with a normal nutritional status. Female sex and rural residence emerged as independent determinants of malnutrition, and a higher burden of patient-reported barriers showed a borderline independent association, whereas treatment burden and facility barriers did not. In parallel, self-reported nonadherence was common and was associated specifically with facility-level barriers rather than with nutritional or demographic status. Together, these findings indicate that nutritional risk and adherence risk are distinct, separately targetable problems in this population.

The prevalence of undernutrition observed here is consistent with the upper range reported for TB populations in comparable settings, where malnutrition typically affects 40–60% of patients [12,13]. This concordance strengthens confidence in the estimate while underlining that malnutrition in TB is the rule rather than the exception in high-burden, low-income contexts. Because undernutrition impairs the immune control of Mycobacterium tuberculosis and is associated with more severe disease and higher mortality, a burden of this magnitude has direct prognostic implications and supports the routine integration of nutritional assessment and support into TB care [21,22,23,24]. The demonstrated benefit of nutritional supplementation on TB outcomes lends further weight to this argument [25].

The independent association of female sex with malnutrition is notable, particularly because an earlier baseline study in Pakistan did not detect a sex difference [26]. Several context-specific mechanisms may explain the disadvantage faced by women. Within many households, women eat last and least, have limited autonomy over food and health spending, and encounter greater difficulty traveling unaccompanied to health facilities—patterns documented for TB care in rural Pakistan [17,27,28]. These gendered constraints plausibly translate into poorer dietary intake and later, sicker presentation. The parallel finding that rural residence independently predicted malnutrition is consistent with the same structural disadvantages—greater poverty, weaker food security, and more limited access to services—that characterize rural populations in the region [29,30].

That treatment and facility burdens were not associated with malnutrition, yet facility barriers were the sole correlate of nonadherence, is itself informative. These findings suggest that nutritional status in this cohort is shaped mainly by upstream social determinants—sex and geography—operating before and around treatment, whereas day-to-day adherence is shaped by the friction of interacting with the health system. The patient-barrier domain, which captures psychological distress, appetite disturbance and difficulty in reaching care, was associated with malnutrition both bivariately and marginally after adjustment, which is consistent with these experiences being more directly related to a patient's ability to eat than to the mechanics of medication collection. Because that association was of borderline significance, it should be regarded as provisional and warrants confirmation. This dissociation echoes qualitative evidence from Pakistan, in which distance from facilities, waiting times, and the practical demands of a long regimen are recurrent barriers to adherence [15,31]. The implication is practical: improving adherence in this setting may depend less on the patient's nutritional or demographic profile than on easing the logistical burden of care—through decentralized drug pick-up, shorter waits, and support with travel.

The near-universal reporting of treatment-related burdens—long regimens, high pill counts, side effects, and costs—mirrors the wider literature on the lived experience of TB treatment and helps explain why adherence remains fragile even when core facility indicators appear adequate [32]. Similarly, the high frequency of psychological distress, with the overwhelming majority reporting low mood related to their illness, is consistent with reports linking TB with depression and with the observation that mental health support is rarely available at the treatment level in Pakistan [33,34]. Although these patient-level burdens were not statistically associated with either outcome here—partly because they were so widely shared that they offered little discriminating variance—they nonetheless describe a patient population under considerable strain and merit programmatic attention in their own right.

This study has several strengths, including the use of an adequately powered sample, the use of a validated multidimensional nutritional instrument, and the simultaneous, adjusted analysis of both nutritional and adherence outcomes. Certain limitations should be considered when interpreting the results. First, the cross-sectional design precludes causal inference; the associations identified describe co-occurrence, not direction. Second, adherence was self-reported over a two-week window and is subject to recall and social desirability bias, which may lead to the underestimation of nonadherence. Third, several barrier items were reported by almost all patients, producing ceiling effects that limit the ability to detect item-level associations; findings for the composite barrier domains should therefore be read as domain-level signals rather than precise effects of individual items. Fourth, although both public- and private-sector facilities were included, the study was confined to two sites in a single city, which may limit its generalizability to other regions or to different resource settings. Fifth, although the false discovery rate was controlled within each family of bivariate tests, the association between facility-level barriers and nonadherence did not survive that correction and rests principally on the adjusted model; it should therefore be regarded as provisional. Finally, some clinically relevant variables, such as HIV status, diabetes status, and disease severity, were not available for adjustment. Future longitudinal, multicenter studies incorporating these variables and objective adherence measures would help clarify the temporal and causal relationships suggested here.

5. Conclusions

Malnutrition or its risk affected the overwhelming majority of adult TB patients attending public- and private-sector hospitals in Lahore, with nearly half already malnourished and most of the remainder at risk. Female sex and rural residence were independent determinants of malnutrition, and women and rural patients were identified as priority groups for nutrition-sensitive TB care. Self-reported nonadherence was widespread and was associated with facility-level barriers rather than with nutritional or demographic status, indicating that nutritional risk and adherence risk require distinct programmatic responses. Integrating routine nutritional assessment and support into TB services—while easing the health-system barriers that impede adherence—offers a practical, evidence-based path to improving outcomes in this high-burden setting.

Abbreviations: aOR, Adjusted odds ratio; CI, Confidence interval; IQR, Interquartile range; LR, Likelihood ratio; MNA, Mini Nutritional Assessment; OR, Odds ratio; SD, Standard deviation; TB, Tuberculosis.

Author contributions: Conceptualization, MKH, and KT; methodology, MKH, and KT; software, KT; validation, MKH; formal analysis, KT; investigation, KT; resources, KT; data curation, KT; writing—original draft preparation, MKH; writing—review and editing, KT; visualization, KT; supervision, MKH; project administration, KT. All authors have read and agreed to the published version of the manuscript.

Use of generative AI and AI-assisted technologies: During the preparation of this work, the authors used Gemini 3 Pro (Google) in order to improve the language, clarity, and readability of the manuscript. After using this tool, the authors reviewed and edited the content as needed and take full responsibility for the content of the published article.

Funding: This research received no specific grant from the public, commercial, or not-for-profit funding agencies.

Trial registration: Not applicable.

Ethics statement and consent to participate: Ethical clearance for this study was granted by the Ethical Review Committee of Hussain College of Health Sciences, Lahore, Pakistan (No. HCHS/2024/ERC/59), and the study was conducted in accordance with the principles set out in the Declaration of Helsinki. Administrative permission was obtained from the participating facilities prior to data collection, and informed consent was obtained from all participants prior to enrollment.

Consent to publication: Not applicable.

Data availability: The data supporting this study's findings are available from the corresponding author, Khadija Tariq, upon reasonable request.

Acknowledgments: None.

Conflicts of interest: The authors declare no conflicts of interest.

Publisher's note: Logixs Journals remains neutral concerning jurisdictional claims in its published subject matter, including maps and institutional affiliations.

References

[1] Goletti D, Meintjes G, Andrade BB, Zumla A, Shan Lee S. Insights from the 2024 WHO global tuberculosis report - more comprehensive action, innovation, and investments required for achieving WHO end TB goals. Int J Infect Dis. 2025;150:107325. https://doi.org/10.1016/j.ijid.2024.107325

[2] World Health Organization. Global tuberculosis report 2024. Geneva: World Health Organization; 2024 [cited 23 August 2025]. Available from: https://www.who.int/teams/global-programme-on-tuberculosis-and-lung-health/tb-reports/global-tuberculosis-report-2024.

[3] Ullah H, Ahmed H, Salman A, Iqbal R, Hussaini SJ, Malikzai A. The rising tide of tuberculosis in Pakistan: factors, impact, and multi-faceted approaches for prevention and control. Health Sci Rep. 2024;7(10):e70130. https://doi.org/10.1002/hsr2.70130

[4] Ozer NT, Gundogan K. The vicious cycle of malnutrition and tuberculosis: a narrative review. J Clin Pract Res. 2024;46(5):444-8. https://doi.org/10.14744/cpr.2024.60895

[5] Sinha P, Davis J, Saag L, Wanke C, Salgame P, Mesick J, et al. Undernutrition and tuberculosis: public health implications. J Infect Dis. 2019;219(9):1356-63. https://doi.org/10.1093/infdis/jiy675

[6] Ter Beek L, Alffenaar JC, Bolhuis MS, van der Werf TS, Akkerman OW. Tuberculosis-related malnutrition: public health implications. J Infect Dis. 2019;220(2):340-1. https://doi.org/10.1093/infdis/jiz091

[7] Bhargava A, Bhargava M, Meher A, Benedetti A, Velayutham B, Sai Teja G, et al. Nutritional supplementation to prevent tuberculosis incidence in household contacts of patients with pulmonary tuberculosis in India (RATIONS): a field-based, open-label, cluster-randomised, controlled trial. Lancet. 2023;402(10402):627-40. https://doi.org/10.1016/S0140-6736(23)01231-X

[8] Vellas B, Guigoz Y, Garry PJ, Nourhashemi F, Bennahum D, Lauque S, et al. The Mini Nutritional Assessment (MNA) and its use in grading the nutritional state of elderly patients. Nutrition. 1999;15(2):116-22. https://doi.org/10.1016/S0899-9007(98)00171-3
[9] Rubenstein LZ, Harker JO, Salvà A, Guigoz Y, Vellas B. Screening for undernutrition in geriatric practice: developing the short-form Mini-Nutritional Assessment (MNA-SF). J Gerontol A Biol Sci Med Sci. 2001;56(6):M366-72. https://doi.org/10.1093/gerona/56.6.M366
[10] Yu Q, Yao R, Lei L, Shao X, Huang L, Xie F, et al. A correlation analysis between nutritional status and physical function in the elderly with pulmonary tuberculosis. PLoS One. 2025;20(9):e0331700. https://doi.org/10.1371/journal.pone.0331700
[11] Obsina D, Kera AM, Zenebe AZ, Teferi S, Taye A, Belachew T. Nutritional status and associated factors among adult tuberculosis patients in public health centres of Horro Guduru Wollega Zone, Oromia Region, Western Ethiopia. J Nutr Sci. 2024;13:e72. https://doi.org/10.1017/jns.2024.79
[12] Shifera N, Yosef T. Undernutrition and its predictors among tuberculosis patients in Southwest Ethiopia. Front Nutr. 2024;11:1450669. https://doi.org/10.3389/fnut.2024.1450669
[13] Endalkachew K, Ferede YM, Derso T, Kebede A. Prevalence and associated factors of undernutrition among adult TB patients attending Amhara National Regional State hospitals, Northwest Ethiopia. J Clin Tuberc Other Mycobact Dis. 2022;26:100291. https://doi.org/10.1016/j.jctube.2021.100291
[14] Wagnew F, Gray D, Tsheten T, Kelly M, Clements ACA, Alene KA. Effectiveness of nutritional support to improve treatment adherence in patients with tuberculosis: a systematic review. Nutr Rev. 2024;82(9):1216-25. https://doi.org/10.1093/nutrit/nuad120
[15] Sanauddin N, Ahmad F, Rahim M, Paracha MA, Khan Z, Qazi FK, et al. Barriers to treatment adherence among patients with tuberculosis: a qualitative study of Pakistani nationals and Afghan refugees. BMJ Open. 2025;15(10):e100882. https://doi.org/10.1136/bmjopen-2025-100882
[16] Soomro MH, Qadeer E, Mørkve O. Barriers in the management of tuberculosis in Rawalpindi, Pakistan: a qualitative study. Tanaffos. 2013;12(4):28-34.
[17] Habib SS, Jamal WZ, Zaidi SMA, Siddiqui JU, Khan HM, Creswell J, et al. Barriers to access of healthcare services for rural women—applying gender lens on TB in a rural district of Sindh, Pakistan. Int J Environ Res Public Health. 2021;18(19):10102. https://doi.org/10.3390/ijerph181910102
[18] Ullah W, Almansour H, Saini B, Fatima R, Gondal SA, Sohaib AU, et al. Delays in the referral, diagnosis, and treatment of tuberculosis patients in a community pharmacy network in Pakistan. J Basic Clin Med Sci. 2025;4(2):65-76. https://doi.org/10.58398/0002.000027
[19] Sinha P, Ponnuraja C, Gupte N, Prakash Babu S, Cox SR, Sarkar S, et al. Impact of undernutrition on tuberculosis treatment outcomes in India: a multicenter, prospective, cohort analysis. Clin Infect Dis. 2023;76(8):1483-91. https://doi.org/10.1093/cid/ciac915
[20] Feyisa JW, Berhanu RD, Lema M, Desalegn M, Merdassa E, Kitila KM, et al. Magnitude and determinants of undernutrition among tuberculosis patients in Ethiopia: systematic review and meta-analysis. BMC Public Health. 2024;24:1698. https://doi.org/10.1186/s12889-024-19220-3
[21] World Health Organization. WHO consolidated guidelines on tuberculosis: module 6: tuberculosis and comorbidities. 2nd ed. Geneva: World Health Organization; 2025 [cited 23 August 2025]. Available from: https://www.ncbi.nlm.nih.gov/books/NBK619209/
[22] Cintron C, Dauphinais M, Fiogbe AA, Dogo MF, Ate S, Adjonou C, et al. Impact of Nutritional Support for Tuberculosis on Intermediate and Terminal Undernutrition and Treatment Outcomes (INSTITUT) study: a protocol for a quasi-experimental study to assess the impact of nutritional support on tuberculosis treatment outcomes in Benin and Togo. BMJ Open. 2025;15(2):e088629. https://doi.org/10.1136/bmjopen-2024-088629
[23] Li A, Yuan SY, Li QG, Li JX, Yin XY, Liu NN. Prevalence and risk factors of malnutrition in patients with pulmonary tuberculosis: a systematic review and meta-analysis. Front Med (Lausanne). 2023;10:1173619. https://doi.org/10.3389/fmed.2023.1173619
[24] Campbell JR, Chan ED, Falzon D, Trajman A, Keshavjee S, Leung CC, et al. Low body mass index at treatment initiation and rifampicin-resistant tuberculosis treatment outcomes: an individual participant data meta-analysis. Clin Infect Dis. 2022;75(12):2201-10. https://doi.org/10.1093/cid/ciac322
[25] Sinha P, Bhargava M, Carwile ME, Dauphinais MR, Tisile P, Cintron C, et al. A roadmap for integrating nutritional assessment, counselling, and support into the care of people with tuberculosis. Lancet Glob Health. 2025;13(5):e967-73. https://doi.org/10.1016/S2214-109X(25)00021-X
[26] Khan NA, Kanwal S, Zaidi SMAS, Rao AA, Irshad F, Ahmad MJ. Assessment of the nutritional status of tuberculosis patients visiting public sector hospitals in Bhakkar district, Punjab, Pakistan. J Basic Clin Med Sci. 2024;3:4-12. https://doi.org/10.58398/0002.000015
[27] Naz L, Ali A, Yasmin S, Trueha K. Geospatial inequalities in women's malnutrition in Pakistan. BMC Womens Health. 2025;25:225. https://doi.org/10.1186/s12905-025-03752-w
[28] Baxter JB, Wasan Y, Hussain A, Soofi SB, Ahmed I, Bhutta ZA. Characterizing micronutrient status and risk factors among late adolescent and young women in rural Pakistan: a cross-sectional assessment of the MaPPS Trial. Nutrients. 2021;13(4):1237. https://doi.org/10.3390/nu13041237
[29] Afridi JR, Jan SA, Asif MF. Assessing inequality of opportunity in access to maternal healthcare services in Pakistan: a quantitative attempt. BMC Health Serv Res. 2025;25:1167. https://doi.org/10.1186/s12913-025-13312-5

[30] Kamal A, Shah GH, Hafeez A, Siddiqa M, Owens C. Mapping geographic disparities in healthcare access barriers among married women in Pakistan: evidence from a nationally representative survey. Healthcare (Basel). 2025;13(19):2448. https://doi.org/10.3390/healthcare13192448
[31] Alipanah N, Jarlsberg L, Miller C, Linh NN, Falzon D, Jaramillo E, et al. Adherence interventions and outcomes of tuberculosis treatment: a systematic review and meta-analysis of trials and observational studies. PLoS Med. 2018;15(7):e1002595. https://doi.org/10.1371/journal.pmed.1002595
[32] Pradipta IS, Idrus LR, Probandari A, Lestari BW, Diantini A, Alffenaar JC, et al. Barriers and strategies to successful tuberculosis treatment in a high-burden tuberculosis setting: a qualitative study from the patient's perspective. BMC Public Health. 2021;21:1903. https://doi.org/10.1186/s12889-021-12005-y
[33] Afaq S, Ayub A, Faisal MR, Nisar Z, Zala, Rehman AU, et al. Depression care integration in tuberculosis services: a feasibility assessment in Pakistan. Health Expect. 2024;27(1):e13985. https://doi.org/10.1111/hex.13985
[34] Todowede O, Afaq S, Adhikary A, Kanan S, Shree V, Jennings HM, et al. Barriers and facilitators to integrating depression care in tuberculosis services in South Asia: a multi-country qualitative study. BMC Health Serv Res. 2023;23:818. https://doi.org/10.1186/s12913-023-09783-z